UNIVERSITI PUTRA MALAYSIA

DESIGN AND EVALUATION OF A MODIFIED CSMA/CD MAC PROTOCOL ON SINGLE-CHANNEL OPTICAL LOCAL AREA NETWORK

KHARINA KHAIRI

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By

KHARINA KHAIRI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, In Partial Fulfilment of the Requirement for the Degree of Master Science

February 2003

To my parents...

Abstract of the thesis submitted to the senate of Universiti Putra Malaysia in partial fulfillment of the requirements for the degree of Master of Science

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February 2003

Chairman : Associate Professor Dr. Mohamad Khazani Abdullah

Faculty : Engineering

The project carried out was a study of a single-channel optical Local Area Network (LAN) based on an improved CSMA/CD protocol that was adapted from the conventional one. The algorithm of the new version of CSMA/CD was developed, and the LAN was comprehensively studied from a performance perspective within two different scenarios, namely, the Fast Ethernet and the Gigabit Ethernet.

The algorithm was developed in Visual Basic 6.0v programming language. This algorithm paved the way for the generation of performance parameters through simulation of the new LAN. The parameters were then studied and compared against corresponding parameters of conventional LAN that are well reported in the literature. The coding of the new algorithm also incorporated a new type of signal known as *'special jamming signal'* that served to stop all nodes from attempting to transmit except the one whose number of transmission attempts matched the maximum value

specified. This resulted in a condition whereby there was no packet loss at all. The algorithm also focused on providing adequate delay, throughput and efficiency that were needed to support the existing LAN.

The results of this study showed that at least two significant contributions; the average delay and the percentage of collisions which were both shown to improve significantly. Additionally, as far as operating environments were concerned, the throughput (measured on a percentage scale) of Fast Ethernet performed better than that of its Gigabit competitor. The difference in their throughput was attributed to the carrier extension mechanism that was employed by the former. Efficiency, on the other hand, did not show any difference in both transmission rates.

The summary of the overall performance of our network showed improvement for all parameters under study: delay, throughput, efficiency and percentage of collisions by using the improved CSMA/CD protocol.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan Ijazah Master Sains

REKABENTUK DAN PENILAIAN PROTOKOL KAWALAN CAPAIAN MEDIA CSMA/CD TERUBAHSUAI KE ATAS RANGKAIAN KAWASAN SETEMPAT OPTIK SALURAN TUNGGAL

Oleh

KHARINA KHAIRI

February 2003

Pengerusi : Profesor Madya Dr. Mohd. Khazani Abdullah

Fakulti : Kejuruteraan

Kajian ke atas Rangkaian Kawasan Setempat optik saluran tunggal berdasarkan protokol CSMA/CD yang telah diadaptasikan daripada protokol asal telah dijalankan. Melalui pengembangan daripada algoritma baru CSMA/CD, kefahaman mengkaji dari perspektif penilaian Rangkaian Kawasan Setempat dilihat ke atas dua senario, iaitu Fast Ethernet dan Gigabit Ethernet.

Algoritma tersebut telah dibangunkan dengan menggunakan bahasa pengaturcaraan Visual Basic 6.0. Algoritma ini memberi laluan untuk menjana parameter-parameter prestasi melalui simulasi daripada Rangkaian Kawasan Setempat yang baru. Parameter-parameter ini kemudiannya dikaji dan dibandingkan terhadap parameter-parameter prestasi asal yang mana telah dilaporkan.

Algoritma baru yang telah direkabentuk di mana telah membawa kepada satu pengenalan iaitu 'isyarat sekatan khas'. Di mana isyarat sekatan ini memberhentikan semua stesen-stesen yang cuba untuk menghantar paket kecuali stesen yang mempunyai nilai percubaan yang sama dengan nilai maksimum yang telah disetkan. Ini menyebabkan satu keadaan di mana tiada berlaku kehilangan paket. Algoritma ini juga difokuskan untuk memperolehi purata lengah masa, truput dan juga kecekapan yang memadai supaya menyokong Rangkaian Kawasan Setempat yang sedia ada.

Keputusan-keputusan daripada kajian ini menunjukkan dua sumbangan utama; purata lengah masa dan peratus pelanggaran, di mana kedua-duanya menunjukkan prestasi yang baik. Prestasi truput ke atas Fast Ethernet lebih tinggi daripada Gigabit Ethernet kerana Gigabit Ethernet menggunakan 'pembawa sambungan' yang menyebabkan truput Fast Ethernet lebih tinggi. Prestasi kecekapan juga tiada bezanya pada kedua-dua kadar penghantaran.

Sebagai rumusan daripada keseluruhan prestasi daripada rangkaian ini telah menunjukkan peningkatan iaitu: purata lengah masa, truput, kecekapan serta peratus pelanggaran dengan menggunakan protokol CSMA/CD yang lebih baik.

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I certify that an Examination Committee met on 6th February 2003 to conduct the final examination of Kharina Khairi on her Master of Science thesis entitled "Design and Evaluation of a Modified CSMA/CD MAC Protocol on Single-channel Optical Local Area Network" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

KHARINA KHAIRI

Date: 5 . 3 . 0 3

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LIST OF ABBREVIATIONS

ANSI	-	American National Standards Institute
ANSI X3T11	-	American National Standards Institute Fiber Channel
BER	-	Bit Error Rate
CSMA/CD	-	Carrier Sense Multiple Access / Collision Detection
DNC	-	Digital Network Architecture
DTE	-	Data Terminal Equipment
EMI	-	Electromagnetic Interference
FC	-	Fiber Channel
FDDI	-	Fiber Distributed Data Interface
FE	-	Fast Ethernet
FTP	-	File Transfer Protocol
Gbps	-	Giga bits per second
GE	-	Gigabit Ethernet
ICT	-	Information and Communication Technology
IEEE	-	Institute of Electrical and Electronic Engineers
IEEE 802.3	-	Ethernet Standard
LAN	-	Local Area Network
LX	-	Long-wavelength
MAC	-	Medium Access Control
MAN	-	Metropolitan Area Network
Mbps	-	Mega bits per second
MMF	-	Multimode Fiber

NIC	-	Network Interface Card
OSI	-	Open System Interconnect
PHY	-	Physical Layer
SDH	-	Synchronous Digital Hierarchy
SMF	-	Single Mode Fiber
SONET	-	Synchronous Optical Network
SX	-	Short-wavelength
UTP	-	Unshielded Twisted Pair
WAN	-	Wide Area Network

LIST OF NOTATIONS

δ	-	Collision Time
t	-	Time
t_w	-	Waiting Time
t_{tx}	-	Transmission Time
t_d	-	Propagation Time
a	-	Propagation Delay
b	-	Length of Jamming signal
y	-	Idle Time
N	-	Node or Station
M	-	Wavelength
$rand( )$	-	Random Number
P_n	-	Poisson Distribution
λ	-	Arrival Rate
n	-	Probability of Success
d	-	Distance
ρ	-	Offered Load
D	-	Average Delay
ξ	-	Throughput
η	-	Efficiency
C	-	Collision
γ	-	Mean Number of Occurance
p	-	Probability

m	-	Number of Trials
X	-	Random Variable
$E(X)$	-	Mean Value of X
$V(X)$	-	Variance of X

CHAPTER 1

INTRODUCTION

1.1 Optical Networks Today

For years, the networking sector has grappled with the notion of the all-optical network. It offers the promise to solve many problems to provide enormous capacities in the network. Optical networking opens up a new field of multimedia applications and also of an enhancement network protocols adapted to high-speed network architectures. In addition, it provides a common infrastructure over which a variety of services can be delivered (Rajiv and Kumar, 2002). More generally known, optical fiber offers much higher bandwidth than copper cable. Therefore, it is natural that many telecommunication providers have moved to the optical fiber cable.

The first modification to the existing networks was performed on the physical layer. The lost cost of the optical fiber and the tremendous increase of bandwidth obtained with this technology convinced the network engineers to invest in the optical devices- such as transmitter, receivers and amplifiers- forecasting on improvement of performances at acceptable costs (McCullough, 2000). Figure 1.1 shows the basic topologies behind the three generations of optical fiber networks. For the first-generation, fiber was not used. For the second-generation, fiber was used as a replacement for copper. For the third-generation, unique fiber properties are exploited.

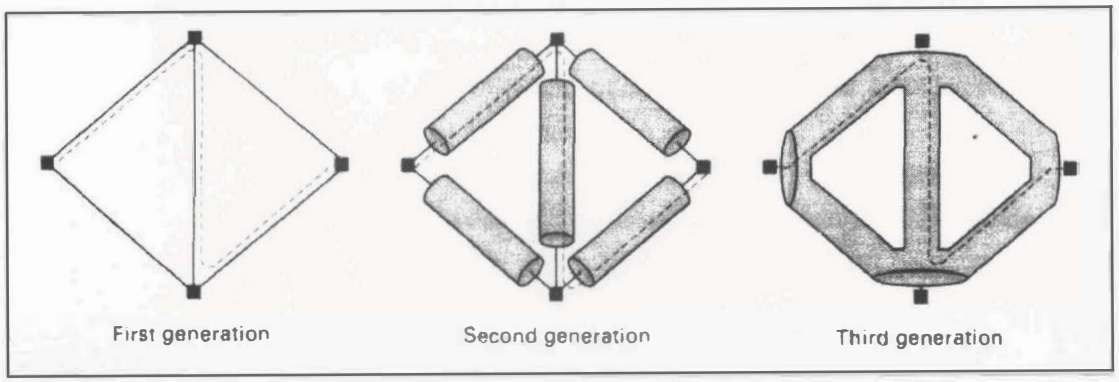

Figure 1.1: The basic idea behind the three generations of fiber usage in networks (Dutton, 1998)

The upper layers of the network would be the same with the previous generation: all the data are transmitted point-to-point in optical forms on the links, but at each node an opto-electronic conversion is performed and the data are analyzed with the usual devices; then they would return in optical form on the next link (McCullough, 2000), (Djafar et. al, 2001). Synchronous Optical NETworks (SONET) and Synchronous Digital Hierarchy (SDH) represent examples for such networks, which are now widely implemented all over the world.

Today we are seeing the deployment of second generation optical networks, where some of the routing, switching, and intelligence is moving into the optical layer (Rajiv and Kumar, 2002). It exploits the intrinsic characteristics of optical domain not only point-to-point transmission, but also for other functions such as the routing process, which is an optical evolution penetration more into the architecture, affecting more than one network layer. Of course an optical network must provide other characteristics beyond high bandwidth capacity: it must be robust, flexible, and cost effective due to an